Distribution and Abundance of Invasive Non-indigenous Plants and Rare Plants at Two Riverine National Parks in the Great Lakes Network

Jennifer Larson
Department of Ecology, Evolution, and Behavior
University of Minnesota
St. Paul, Minnesota 55108

Diane Larson
USGS Northern Prairie Wildlife Research Center
Minnesota Field Station
St. Paul, Minnesota 55108

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ABSTRACT

Invasion by non-indigenous plants is widely considered to be a primary threat to species diversity and ecosystem function. Ecosystem changes resulting from these invasions may negatively impact native plant communities as a whole, as well as rare and endangered species. This report explores existing reports on rare plant locations in Mississippi National River and Recreation Area (MISS), and Saint Croix National Scenic Riverway (SACN). No rare plant surveys were performed for this study. In addition, we performed invasive plant surveys on several species considered "target" species of concern at each park. Common buckthorn (*Rhamnus cathartica* L.) was the most commonly found invasive species. Of the 68 plots sampled in MISS, 53 had at least one invasive species present, and of the 136 plots sampled in SACN, 128 had at least one invasive species present. While this was not an exhaustive attempt to survey all invasive infestations, this study can serve as a template for future surveys and to emphasize the importance of continuity to allow compilation and comparison of data across parks.

INTRODUCTION

Invasion by non-indigenous plant species is widely considered to be a primary threat to native species diversity and ecosystem function (Vitousek and Walker 1989, D'Antonio and Vitousek 1992, Lesica and DeLuca 1996, Gordon 1998, Ley and D'Antonio 1998). Effects have been documented both belowground, in terms of nutrient cycling and soil chemical and biotic properties (Vitousek and Walker 1989, Christian and Wilson 1999, Chen and Stark 2000, Klironomos 2002) and aboveground, in terms of fire (Knapp 1996) and hydrologic regimes (LeMaitre et al. 1996, Gordon 1998) and community composition and structure (Billings 1993, Eliason and Allen 1997). Broad ecosystem changes such as these may have detrimental effects on native plant communities as a whole, as well as rare and endangered species which are often specialized to particular habitats (US Congress Office of Technology Assessment 1993). Thus, long-term monitoring and continued management of invasive plant populations is crucial to maintaining the integrity of ecosystems, and to preservation of rare and endangered plants.

The Mississippi National River and Recreation Area (MISS) is a 72-mile expanse of the Mississippi River, with the Minneapolis/St. Paul, MN metro area at its center. Though the Park Service owns only 35 acres, mainly islands, of the 54,000 acres included in MISS, park staff participate in decisions regarding management of city, county, and state open spaces and parks within the MISS boundary. Thus they need up-to-date information on species of concern within the corridor, including rare and invasive species.

Saint Croix National and Scenic Riverway (SACN) encompasses 92,748 acres along and including the St. Croix River, which provides portions of the border between Minnesota and

Wisconsin. Unlike MISS, SACN staff have control over most of the property within the park boundary and develop management plans for it. Data on locations of rare species and invasive species are critical to the development of appropriate burn plans and exotic plant control efforts.

MISS and SACN requested two outcomes from the current study. First, they wanted a record of results of any rare plant surveys that had not already been incorporated into databases available to the parks. Second, they requested an inventory of invasive plants within park boundaries, with an emphasis on particular species (see below). In addition, SACN wanted (1) an idea of the northern boundary of common buckthorn along the St. Croix River and (2) a more detailed survey of a burn unit.

Target invasive species

Target invasive species identified by MISS were common buckthorn, black locust (*Robinia pseudoacacia* L.), tartarian honeysuckle (*Lonicera tatarica* L.), garlic mustard [*Alliaria petiolata* (Bieb.) Cavara & Grande.], and reed canarygrass (*Phalaris arundinacea* L.). At SACN, target invasive species were common buckthorn, spotted knapweed (*Centaurea biebersteinii*. DC.; formerly known as *Centaurea maculosa*), cypress spurge (*Euphorbia cyparissias* L.), leafy spurge (*E. esula* L.), reed canarygrass, tartarian honeysuckle, and Canada thistle (*Cirsium arvense* (L.) Scop.). Taxonomy follows the USDA Plants Database (USDA, NRCS 2004).

Common buckthorn. Common buckthorn is native to Europe, and was likely introduced to North America prior to 1800 (Wyman, 1971). Buckthorn quickly develops dense, even-aged stands, which drastically limit light availability to the forest floor. Recent studies have shown increases in the mineralization of nutrients with decomposition of buckthorn litter, which may alter fertility at sites which have been invaded (Heneghan et al. 2002). Knight and Reich (2005) found that cover of common buckthorn was negatively related to both native species richness and cover at the scale of 1 m^2 patches but was positively related to native species richness at larger landscape scales. Such scale-related changes emphasize the importance of considering the scale at which measurements were made when interpreting the data presented here. Buckthorn seems to invade areas suitable for a variety of native species. However, species richness is low within the invaded patches. Whether this is a result of the invasion, or whether buckthorn specifically invades low diversity sites, is unclear.

Black locust. Black locust is a native of North America, though its original range is in the Appalachian Mountains, below an elevation of 1,067 meters (Converse 1984). It has an extensive fibrous root system, making it tolerant to dry sites, and it reproduces rapidly by vegetative growth and clonal spread. Black locust is a legume, and can enhance soil nitrogen mineralization rates when invading nutrient-poor sites (Rice et al. 2004). The bark may be toxic if ingested (Hui et al. 2004). We found no evaluation of control methods in the published literature.

Tartarian honeysuckle. Tartarian honeysuckle is a shrub native to West-central Eurasia. It grows rapidly and produces copious quantities of showy bird-dispersed berries (Woods 1993)

which may contribute to its rapid spread. Deer have also been shown to be effective dispersers of Tartarian honeysuckle (Vellend 2002). Woods (1993) showed a decrease in total herbaceous species cover and richness, and the density of tree seedlings was lower when cover of Tartarian honeysuckle exceeded ca. 30% in mesic forest stands. Luken et al. (1997) showed that amur honeysuckle (*Lonicera maackii*) was better able to utilize increased light, as one would find after disturbance or along roads and trails, than was the native shrub, *Lindera benzoin*. If Tartarian honeysuckle is at a similar competitive advantage, increasing fragmentation will likely favor the increased distribution of this invasive honeysuckle.

Garlic mustard. Garlic mustard is an obligate biennial herb in the family Brassicaceae. It is self-fertile and has proven difficult to eradicate once established (Nuzzo 2000). Seed rain has been estimated at 15,000 seeds/m^2, although most seeds germinate the following spring and seedling survival to maturity is relatively low (Anderson et al. 1996). Garlic mustard's habit of early leaf emergence may contribute to its success in North American forests, where it is the first species to green up in the spring (Myers and Anderson 2003). Recent evidence suggests that, with increased residence time, garlic mustard declines (Blossey, Cornell University, pers. comm.), suggesting the potential for negative density dependence in mature populations. Potential impacts of garlic mustard invasion include decreases in native herbaceous richness and cover (Nuzzo 2000), although Davalos and Blossey (2004) could detect no effect of garlic mustard on ground beetle assemblages. Extracts from garlic mustard roots have been shown to be toxic to mycorrhizal fungi and to other plants (Vaughn and Berhow 1999, Roberts and Anderson 2001). A biological control program for garlic mustard is underway (Blossey et al. 2001) and Minnesota is a participant (L. Skinner, MNDNR, pers. comm.). Carlson and Gorchov (2004) used glyphosate to treat experimental plots within infested forests in Ohio in November and found a reduction in garlic mustard with little harm to the native plant community; spring ephemerals were especially favored by this treatment.

Reed canarygrass. Though reed canarygrass is native to North America, aggressive ecotypes have been introduced from Europe (Maurer et al. 2003). The form that typically invades wetland areas is thought to be the non-native ecotype, or a hybrid of the native and non-native ecotypes. Traits that make it an aggressive invader include high allocation to reproduction, clonal growth, and long growing period, among others (Marten and Heath 1985, Apfelbaum and Sams 1987). Impacts include displacement of vegetation in restored and native wetland communities (Galatowitsch et al. 1999). Few control techniques have shown promise. However, a combination of carbon addition to reduce nitrogen availability and competitive planting of a native sedge proved effective in one study (Perry and Galatowitsch 2004). Decreased flow in some riverine habitats has been linked to the ability of reed canarygrass to invade these areas (Barnes 1999), suggesting that restoration of peak flows may suppress invasions. Paveglio and Kilbride (2000) recommended that control of reed canarygrass not be initiated in wetlands until seasonal water levels can be consistently managed.

Spotted knapweed. Spotted knapweed is a native of Europe and was likely introduced to North America in the 1890's (Maddox 1979). Invasion of spotted knapweed has been linked to a decline in species richness (Tyser and Key 1988, Mauer et al. 1987, Kedzie-Webb et al.

2001). Ridenour and Callaway (2001) determined that allelopathy was primarily responsible for negative effects of spotted knapweed on a species of *Festuca*. Spotted knapweed has been shown to be particularly adept at using native mycorrhizal fungi to the detriment of native plant species (Callaway et al. 2004, Carey et al. 2004). Most research on spotted knapweed has been conducted in the west, Montana in particular, so its applicability to conditions in the Midwest are unknown. Several herbicides have been used effectively on spotted knapweed in Montana with little persistent detriment to native plant communities (Rice et al. 1997). Biological control agents have been released for spotted knapweed. Gall flies (*Urophora* species) have been shown to change habitat selection patterns of deer mice, which feed on the galls preferentially and may reduce populations of the insects below that necessary to control the knapweed (Pearson et al. 2000). In addition, overcompensation for herbivory may actually increase the competitive ability of spotted knapweed in the presence of biocontrol insects (Callaway et al. 1999).

Cypress spurge. Cypress spurge is a semi-woody perennial which superficially resembles a young conifer (Stahevitch et al. 1988). It has an extensive root system and efficient seed-dispersal, which make herbicidal and other chemical control difficult (Stahevitch et al. 1988). Control of cypress spurge, once established, is difficult due to its extensive root system, and its ability to regrow from roots following any destruction to above-ground parts (USDA 2005). In open habitat, several species of *Aphthona* flea beetles have proven a successful management tool for this species. Cypress spurge, along with leafy spurge, could be detrimental to burn units established at SACN, many of which include open prairie sites.

Leafy spurge. Leafy spurge is a long-lived perennial plant with an extensive root system (Watson 1985). The extent of the root system makes the plant highly resistant to most traditional weed control techniques, since remaining root fragments may produce shoots from more than a meter below the soil surface (Best et al. 1980). Seeds remain viable for at least 8 years (Selleck et al. 1962), so any efforts at control must be long-term. Biological control is seen by many as the most cost-effective means of reducing populations of leafy spurge, particularly in rangeland and natural areas (Hansen et al. 1997, Lym 1998). In Minnesota, flea beetles (*Aphthona spp.*) have received the most attention as potential agents of control, having been released throughout the state (Skinner, pers. comm.). Studies carried out in east-central and western North Dakota have demonstrated declining biomass and stem counts of leafy spurge at flea beetle release sites (Kirby et al. 2000)

Canada thistle. Canada thistle is commonly found on fertile, mesic soils (Nuzzo 1997). It is shade intolerant and seedlings compete poorly with other vegetation. Most spread is vegetative (Donald 1990), although considerable spread via seed has been documented in arable fields (Hettwer and Gerowitt 2004). Very small (2 cm) root fragments are capable of producing new vegetative shoots (Nadeau and Vanden Born 1989). Mowing of the main shoot stimulates sprouting from other root buds, so that more vegetative stems are produced. Shoot density increases in the year following high precipitation (Nuzzo 1997). Shoot production of established clones is positively correlated with nitrogen availability in soils. Increased shoot growth with N fertilization is the result of increased root growth in the top 20 cm of soil, rather than greater density of buds (Nadeau and Vanden Born 1990). Although it is thought that seed dispersal accounts for a relatively small amount of spread, new

infestations are likely the result of seedling establishment (Heimann and Cussans 1996). Seed production mostly relies on pollination, usually by honeybees, since plants are dioecious, albeit imperfectly (males may produce some viable seed) (Lalonde and Roitbert 1994). Seed buried in soil remains viable for up to 20 years (Nuzzo 1997).

Although biological control agents have been approved for Canada thistle, they have proven ineffective in most cases (Reed et al., in press). Recent experimental work also documents increased below-ground allocation under elevated and ambient CO_2, compared with CO_2 levels measured at the beginning of the twentieth century, and subsequently greater resistance to herbicide application (Ziska et al. 2004). Canada thistle will likely present one of the most vexing weed issues in the foreseeable future.

OBJECTIVES

Documentation of rare plant occurrence. One objective for this project was to perform an exhaustive search for rare plant surveys in existence, including unpublished reports, that might not have been available to MISS or SACN previously.

Development and testing of exotic species survey methods. In the first year of this study, our objective was to develop and test methods for field surveys to be performed the following field season. Reviewers had been skeptical of the methods proposed in our initial study plan. Specifically, we wanted to determine efficient and useful measures of invasive species occurrence and abundance that could be compared among and within forest types and that would give managers sufficient information to prioritize future survey and management efforts.

Field surveys for invasive species. In the second and final year of the field study (2004), our goal was to survey invasive species using methods developed the previous year.
Our objectives were to determine cover and age class of each target species at sample points throughout public lands within the MISS corridor and at systematically located points along the SACN corridor. In addition, an objective at SACN was to determine the northern range of common buckthorn along the St. Croix River and to survey invasive species within the designated burn unit. The burn unit was sampled in order to obtain baseline data of the site prior to burning, and goals of the SACN fire management plan include maintaining prairies and prairie plant communities by reducing non-native plants (Robin Maercklein, NPS, pers. comm.).

METHODS

Documentation of rare plant occurrence

We consulted lists of federal and state endangered and threatened plants to determine species on which to focus the inventory in 2003. We contacted state, county and city parks within the MISS corridor via telephone and email and asked about the presence of rare plant surveys within their jurisdictions. Existing location data from the Judziewicz and Iltis (1994) report, paper maps, and other sources were collected, converted to Universal Transverse Mercator (UTM) coordinates when possible, and formatted such that they were compatible with ArcGIS. The ranking system used to define the accuracy of each occurrence is described in Table 1.

Records that lacked sufficient precision to determine UTM coordinates have been cataloged separately in an Excel worksheet. Data from paper topographic maps were transferred to digital raster graphic (DRG) maps. These maps are geo-referenced and data have been transferred from paper maps into UTM coordinates that are now incorporated into an ArcGIS data layer.

Table 1. Ranking system for assessing confidence of each documented rare plant occurrence in Judziewicz and Iltis (1994) and unpublished reports.

Confidence level	Definition
5	Text within the report matches topographic map
4	Historic site not relocated by author(s) of reports; text within the report matches topographic map. No polygons were created for such sites
3	Text within reports disagrees with topographic map
2	No map for text within the given report
1	No text within the report for map
0	Sites not mapped, due to no state status or lack of information as described by confidence level definitions above.

Development and testing of exotic species survey methods

In 2003, we tested the methods we had proposed in the approved study plan, taking into account reviewers' remarks regarding utility of the data and breadth of sampling. Transects adjacent to rare plant locations were established and plots were evaluated for species composition and stem counts of invasive species. As an alternative, we tested random plots in which cover of invasive species was measured on varying numbers of quadrats and native plant community and dominant species were recorded. These methods were tested at Battle

Creek Regional Park and Coon Rapids Dam within the MISS corridor. For efficiency, we briefly describe the shortcomings of these methods here, and then describe in detail the methods we ultimately used for the 2004 survey.

Originally proposed methods: Species composition within 8 plots, each 3 m apart along the transect, was recorded. Plots consisted of a 0.5 x 1.0 m PVC frame divided into six subunits with narrow metal rods; the final (7th) subunit results from flipping the plot frame over. Dimensions are as follows:

Subunit number	dimensions (cm)
1	6.25 x 12.5
2	12.5 x 25.0
3	12.5 x 50.0
4	25.0 x 50.0
5	25.0 x 100.0
6	50.0 x 100.0
7	50.0 x 200.0

This method proved inefficient at gathering the pertinent invasive species information we required, as it focused too heavily on species composition. It became clear from our field tests of sampling methods that a broader estimation of invasive species cover, rather than plot-based stem counts, would be necessary when mapping invasive infestations.

Modified methods: We sampled several random points within the park. Random points were used because locations of invasive species were widespread, and UTM data for specific infestations at each park were unavailable. At randomly selected points within the park, we measured buckthorn and honeysuckle density in a 2 m^2 plot. Density was defined as number of stems within the 2 m^2 plot. The original idea was to determine density in a minimum of 4 plots, counted along each of 2 transects, one parallel and one perpendicular to the river, crossing at the approximate center of the infestation. However, this method contained the assumption that infestations were finite, or having a definite edge, which turned out to be false in many of the infestations we sampled while testing this method. The method we ultimately chose for our invasive species survey in 2004 is described below. No results from these preliminary survey tests are given in this report.

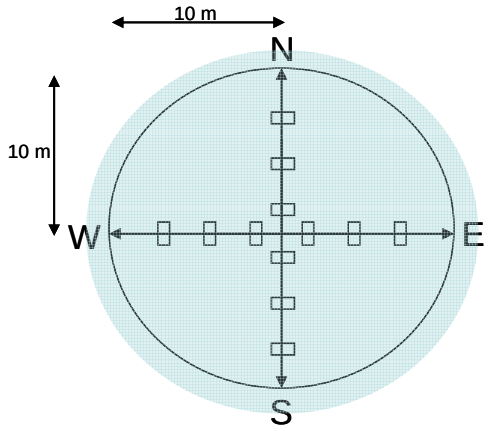
Field surveys for exotic species

Plant surveys within the MISS corridor were limited to public lands, including parks under the management of individual cities, counties, and the state. No federal land was sampled in the MISS corridor. Because time did not permit a systematic sampling of each park, we generated random points using the Random Point-in-Polygon Generation Program v.2 (Sawada 2002). In 2004, we surveyed one point for every 45 hectares (111.2 acres) of land, excluding large areas of water, pavement, or lawn when possible. Aerial photos from the Minnesota Department of Natural Resources (MN DNR) allowed for an estimation of usable area. A Garmin GPS V unit was used to navigate to the potential sample point, and the native plant community was classified using *Field Keys to Minnesota's Forested Native*

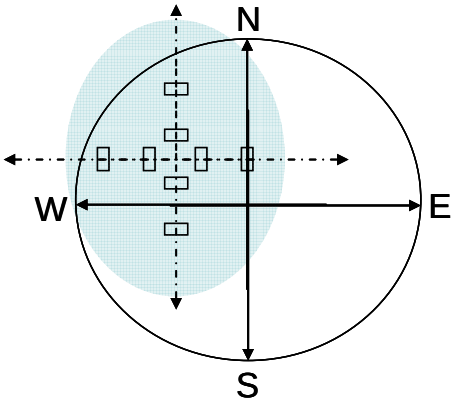
Plant Communities Version 1.0 (MN DNR, July 2002 draft). Unknown plant species were identified using the Manual of Vascular Plants of Northeastern United States and Adjacent Canada (Gleason and Cronquist 1991). A 20 m diameter plot with the random point at the center was established, and flags were placed 10 m from the center to the north, south, east and west (Figures 1a-d). Within each plot we sampled as few as 6, or as many as 9 quadrats (0.5 x 2 m), depending on the size of the infestation. If one or more target invasive species was found in the plot, the size and expansion of the infestation were characterized with one of the following options: the infestation was continuous (Figure 1a), the infestation was continuous, but only a portion was within the plot (Figure 1b), the infestation had a defined edge, a portion of which lies within the plot, and a minimum of 6 quadrats could be sampled (Figure 1c), or the infestation has a defined edge, but the minimum of 6 quadrats could not be sampled, in which case a percent cover of the entire infestation was determined (Figure 1d). Quadrats were placed along the north, south, east, and west of the center point of the infestation, 3 m apart. Estimates of percent cover at each quadrat were divided into life stages of the plant including adult, sapling (for woody species), and seedling.

Figures 1a.-1d. Four methods of characterizing infestations at the Mississippi National River and Recreation Area and St. Croix National Scenic Riverway, 2004. The sample area is centered on the directional cross-hairs. Blue shaded areas are infested. A dark line around the infested area implies an edge to the infestation; lack of a line implies that the infestation continues beyond the observer's field of view. Blocks along perpendicular axes represent quadrats.

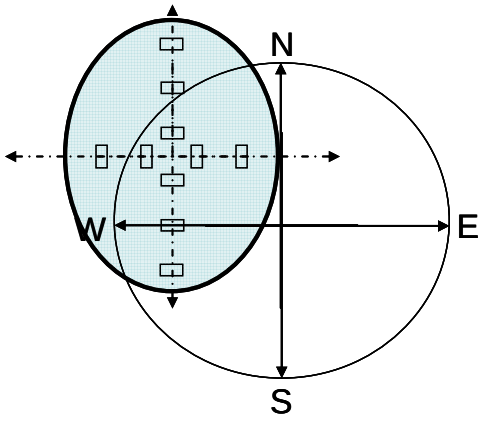
a. continuous



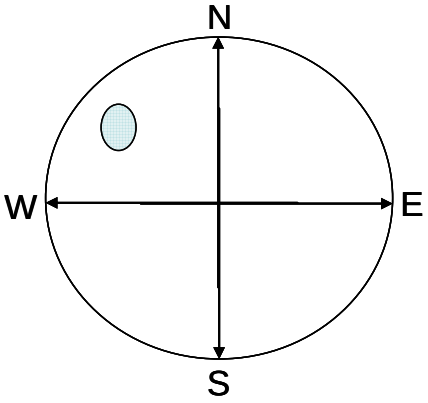
b. continuous, partially in plot



c. finite, partially in plot



d. finite, in plot, too small for quadrats



Daubenmire cover classes (Daubenmire 1959) were used to quantify percent cover of the invasive species within the plot. Midpoints of each cover class were used in calculations of average cover (Daubenmire 1959). The cover classes and the midpoint used to represent each class are as follows:

Daubenmire (1959) cover class	Midpoint
0%	0%
0-5%	2.5%
5-25%	12.5%
25-50%	37.5%
50-75%	62.5%
75-95%	87.5%
95-100%	97.5%

Field surveys at SACN differed in that survey plots were systematically chosen and sampled. Surveys were performed at mile marks, to determine the northern boundary of buckthorn, as well as at campsites and boat landings. We navigated to mile marks from a GIS layer delineating the St. Croix River and used them to locate a point on a line perpendicular to the river and 20 m from the shoreline. We then performed plot surveys matching those at MISS. Four plots were sampled at each campsite. Campsites all have in common a primitive toilet, and the four center points for the plots sampled were located 20 m to the north, south, east, and west of the toilet. At boat landings, two or more plots were sampled, 20 m in from each edge of the boat landing and 20 m in from the river; edges were the defined zone between mowed lawn or paved area associated with the landing and the forest. A third plot was sampled if the shape of the landing permitted. For all sites on both rivers, plant communities were characterized using Native Plant Communities of Minnesota: The Laurentian Forest Province (MN DNR 2003). While the field guide was created for Minnesota, we assumed that sufficient similarities exist between the west and east shorelines of the St. Croix River to make the categories useful. Appendix 1 lists native plant communities classified at MISS and SACN, along with brief descriptions and indicator species.

In addition to the mile marks, campsites, and boat landings, we also surveyed one potential burn unit, located on the SW corner of 220th Avenue and Rice Lake Road in St. Croix County, WI. Data are included in an Excel spreadsheet and as a layer in the ArcGIS project.

Definitions of headings within the database for each park are listed in Appendix 2.

RESULTS

Documentation of rare plant occurrence

Rare plant survey information available for MISS included the MN DNR Natural Heritage Program dataset, to which the park already has access. We found no rare plant surveys within the MISS boundary that had not already been incorporated into the MN Natural Heritage database.

Rare plant survey information available for SACN included the Judziewicz and Iltis report from 1994. This report consists of information including federal and state status, SACN status, historically known populations within the riverway, discoveries of new populations and monitoring recommendations for all vascular plant species listed as threatened, endangered, or of special concern by the MN and WI Heritage Programs. Judziewicz and Iltis performed a baseline inventory of rare plants in the entire riverway during 1992 and 1993. In addition, a monitoring component was developed to assess threats to habitat, primarily anthropogenic, and develop management strategies to assuage these potential threats. We created a database from this report, as well as an ArcGIS data layer linked to this database. No additional rare plant surveys were performed for this study.

Development and testing of exotic species survey methods

Based on the preliminary surveys we did in 2003, we found that some of the methods we had proposed would be impractical in these forested habitats. In 2003, we extracted the invasive species layer from the Minnesota Land Cover Classification System (MLCCS) data and generated random sample points to provide a starting point for surveys in MISS. It became clear from our field tests of sampling methods that a broader estimation of invasive species cover, rather than plot-based stem counts, would be necessary when mapping invasive infestations. In addition, rather than identifying each species in a plot, it was decided that the native plant community classification would be more useful as well as more efficiently described.

Field surveys for invasive species

We sampled 68 plots in MISS in 2004, of which 53 had at least one invasive species present. The park with the fewest invasive species was Gores Pool WMA. Parks with the least cover of invasive species were Lilydale and Crosby Farm.

At SACN in 2004, we sampled 45 plots at campsites, of which 38 had invasive species. We sampled 17 plots at boat landings, of which all had invasive species. On average we found 2 invasive species at a given sample location.

Invasive species included in the survey are listed in Table 2. Note that not all species occurring in the target species list (see introduction) for each park were included in the survey, for lack of their presence in the survey plots. In addition, several non-native species (some considered invasive) not designated as target species by MISS or SACN were

surveyed, as they have potential to alter community composition and facilitate ecosystem-level changes.

Table 3 contains descriptions of non-woody species life stage forms. Average percent cover of target invasive species infestations for each park in MISS, by native plant community, are illustrated in Figures 2 - 6. Average values were calculated over the entire plot, or the sum of the cover class midpoints in each quadrat divided by the number of quadrats. Summary tables for these figures are in Appendices 3-7.

Average percent cover of target invasive species infestations for boat landings and campsites in SACN, by native plant community, are illustrated in Figures 7-11. Summary tables for these figures are in Appendices 8-12.

Table 2. Invasive plants surveyed at Mississippi National River and Recreation Area and Saint Croix National Scenic Rverway, 2003-2004.

MISS (total plots sampled = 68)	SACN (total plots sampled = 136)
Alliaria petiolata (garlic mustard)	*Alliaria petiolata*
Bromus inermis (smooth brome)	*Arctium minus* (burdock)
Carduus nutans (nodding thistle)	*Bromus inermis*
Centaurea biebersteinii (spotted knapweed)	*Centaurea biebersteinii*
Cirsium arvense (Canada thistle)	*Cirsium arvense*
Lonicera tatarica (Tartarian honeysuckle)	*Cirsium vulgare* (bull thistle)
Phalaris arundinacea (reed canarygrass)	*Lonicera tatarica*
Rhamnus cathartica (common buckthorn)	*Lythrum salicaria* (purple loosestrife)
Robinia pseudoacacia (black locust)	*Melilotis alba* (white sweetclover)
Salsola collina (Russian thistle)	*Phalaris arundinacea*
	Rhamnus cathartica
	Robinia pseudoacacia
	Syringa vulgaris (common lilac)

Table 3. General descriptions of non-woody species adult and seedling forms. Most non-woody plants surveyed were adults, with the exception of garlic mustard.

Species	Adult description	Seedling description
Garlic mustard	Flowering, or nearly so	Ground-cover level leaf
Smooth brome	Clonal patch	Individual not connected by rhizomes to other individuals
Noddling thistle	Flowering, or nearly so	Rosette of leaves
Spotted knapweed	Flowering, or nearly so	Rosette of leaves
Canada thistle	Flowering, rhizomatous	Rosette of leaves, unattached to any adult plant(s)
Reed canarygrass	Clonal patch	Individual not connected by rhizomes to other individuals
Russian thistle	Flowering, or nearly so	Leaves have a temporary mucronate tip within the notched apex
Common burdock	Much-branched stem	Many-leaved rosette
Bull thistle	Flowering, or nearly so	Rosette of leaves
Purple loosestrife	Large, flowering stems or collections of stems	Smaller version of adults
White sweetclover	Flowering	Smaller, non-flowering

Figure 2. Average percent cover common buckthorn at Mississippi National River and Recreation Area in 2004, by native plant community. Percent cover is separated into adult (>3 m), sapling (<3 m), and seedling (ground cover, not connected by root suckers to any adult or sapling). Please note that Figure 2 continues on the next page. The number of plots sampled at the given park is denoted by "n".

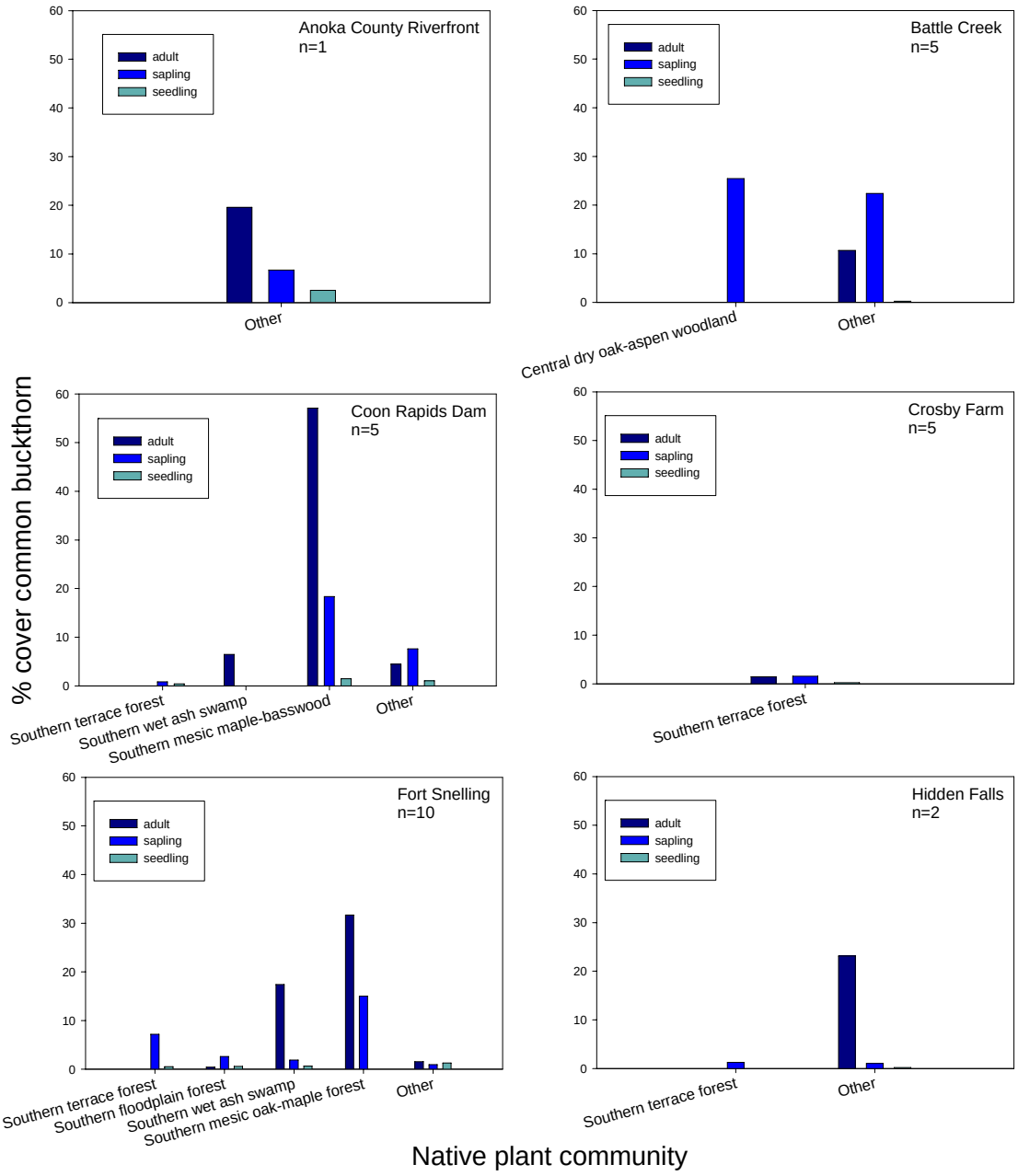


Figure 2 continued.

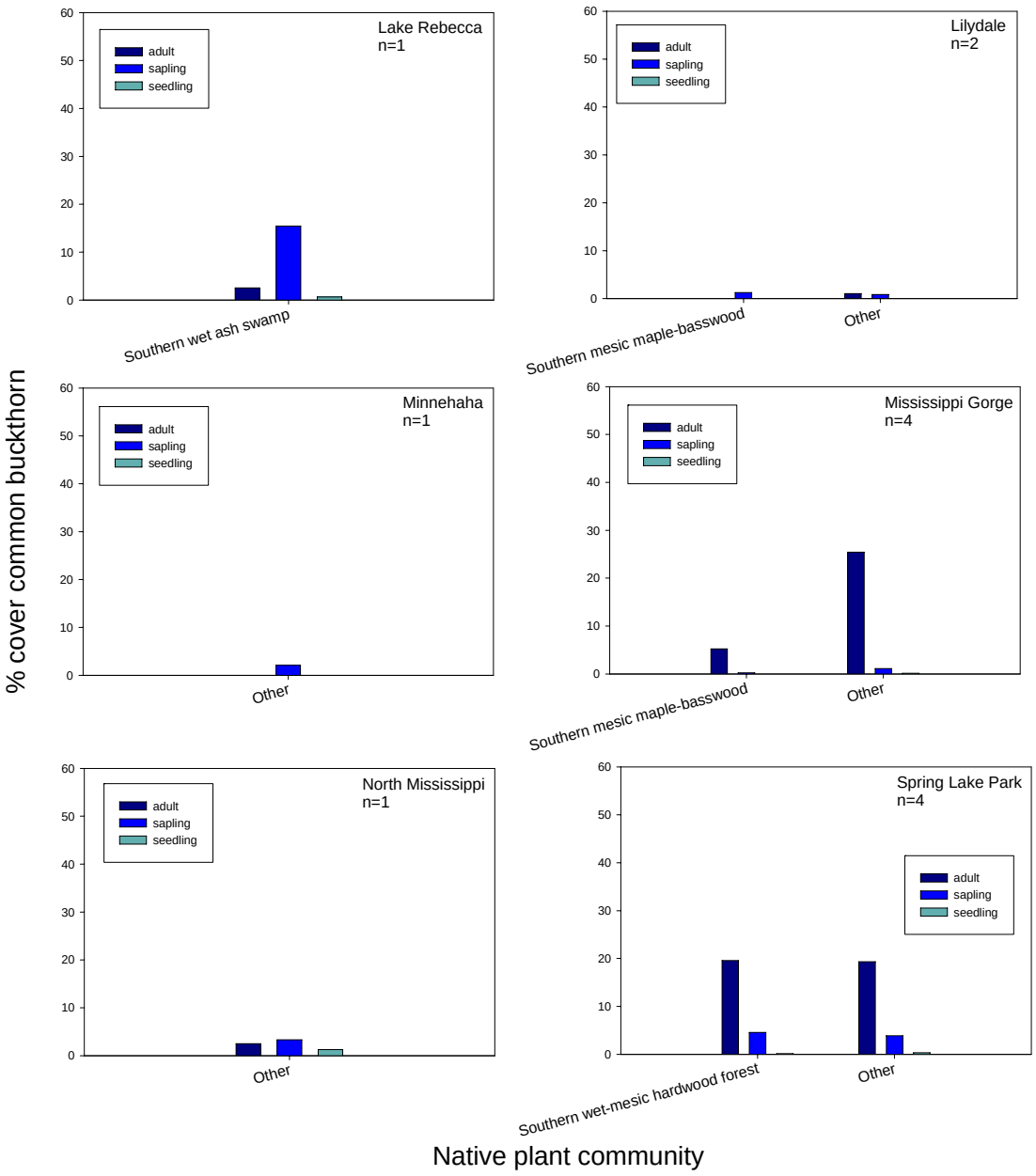


Figure 3. Average percent cover Tartarian honeysuckle by native plant community at Mississippi National River and Recreation Area in 2004. Percent cover is separated into adult (>1.5 m), sapling (<1.5 m), and seedling (ground cover, not connected by root suckers to any adult or sapling). Please note that Figure 3 continues on the next page. The number of plots sampled at the given park is denoted by "n".

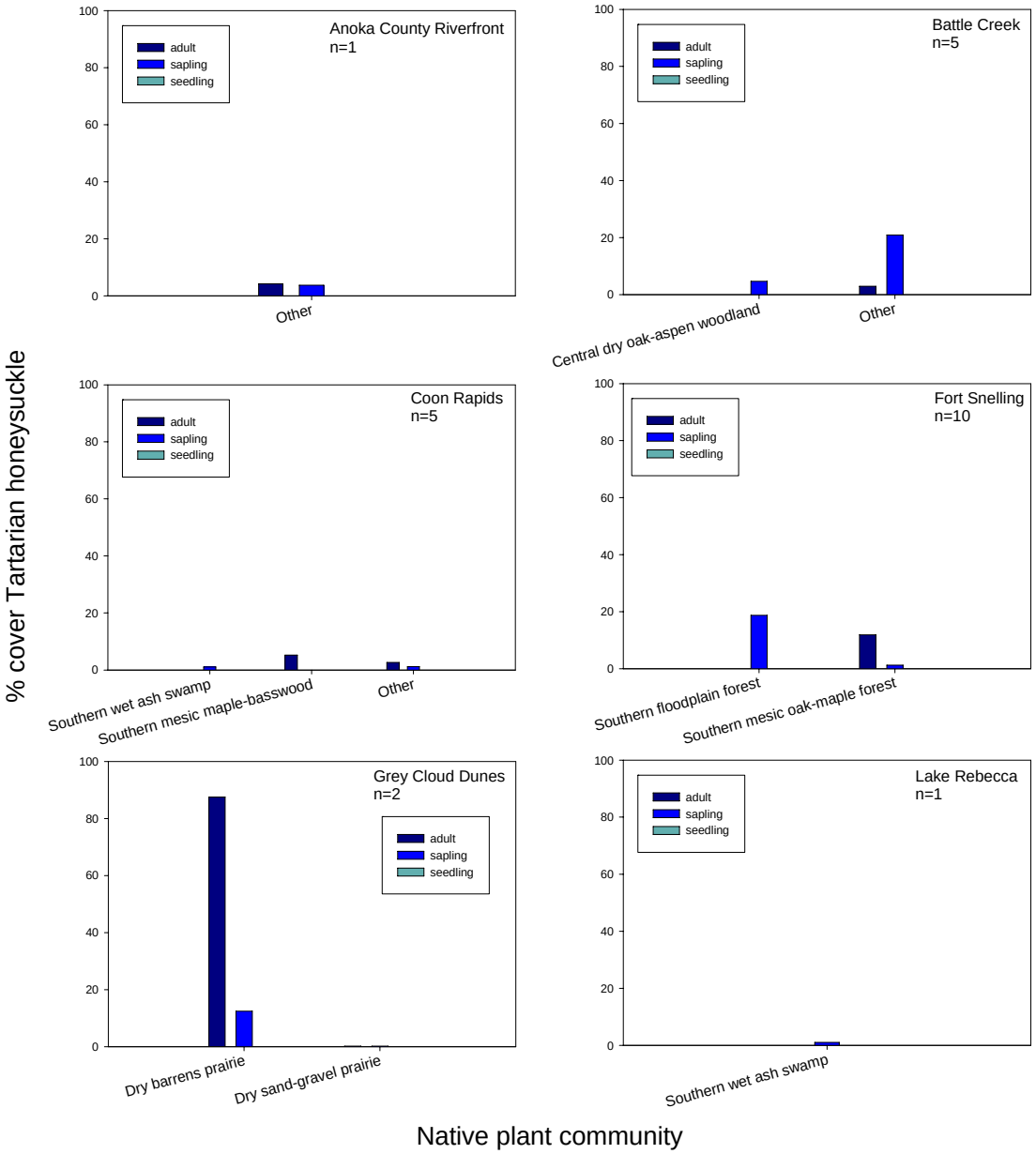


Figure 3 continued.

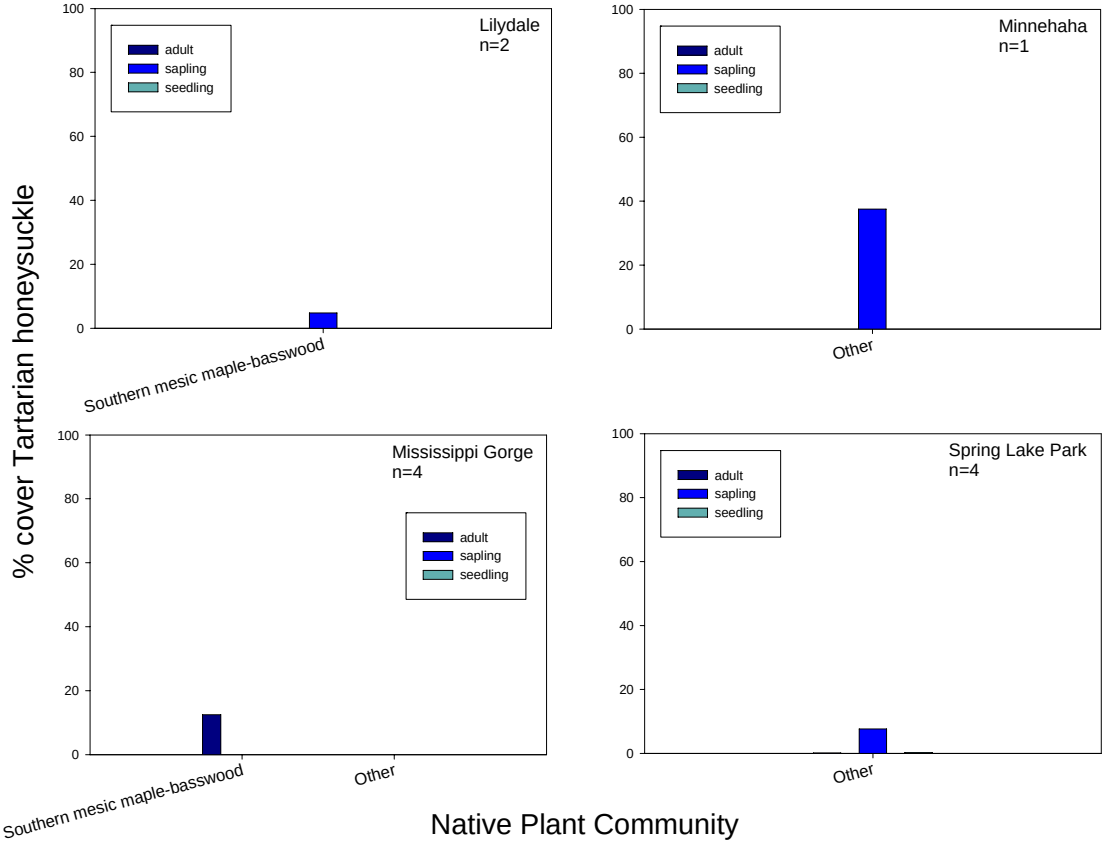


Figure 4. Average percent cover garlic mustard by native plant community at Mississippi National River and Recreation Area in 2004. If no bar is present for average percent cover the species was present within the selected plot, but not present in any of the quadrats, which represent a subsample of the plot. Non-woody species are separated into adults or seedlings, the definitions of which vary among species (Table 3). The number of plots sampled at the given park is denoted by "n".

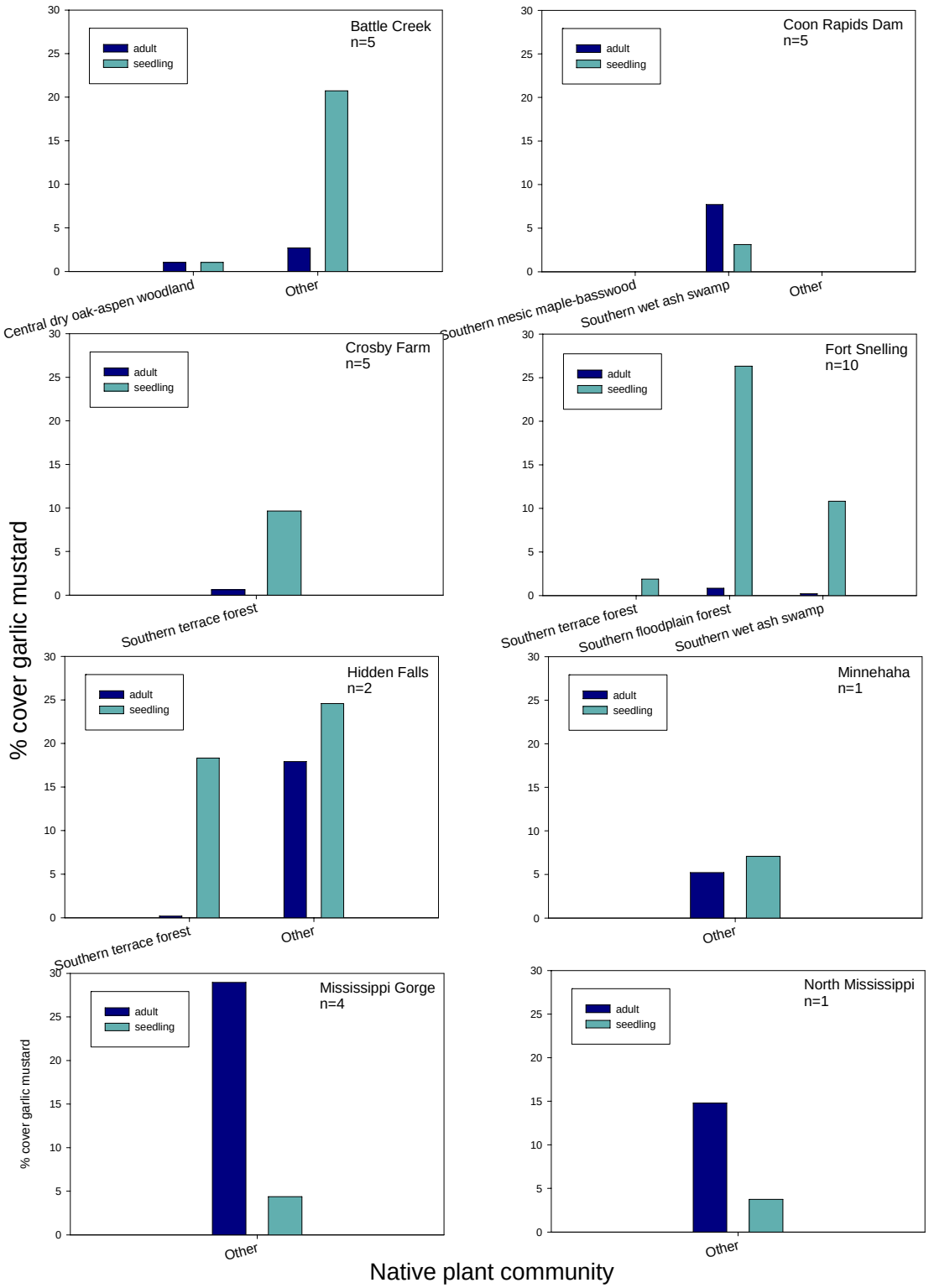


Figure 5. Average percent cover reed canarygrass by native plant community at Mississippi National River and Recreation Area in 2004. Non-woody species are separated into adults or seedlings, the definitions of which vary among species (Table 3). The number of plots sampled at the given park is denoted by "n".

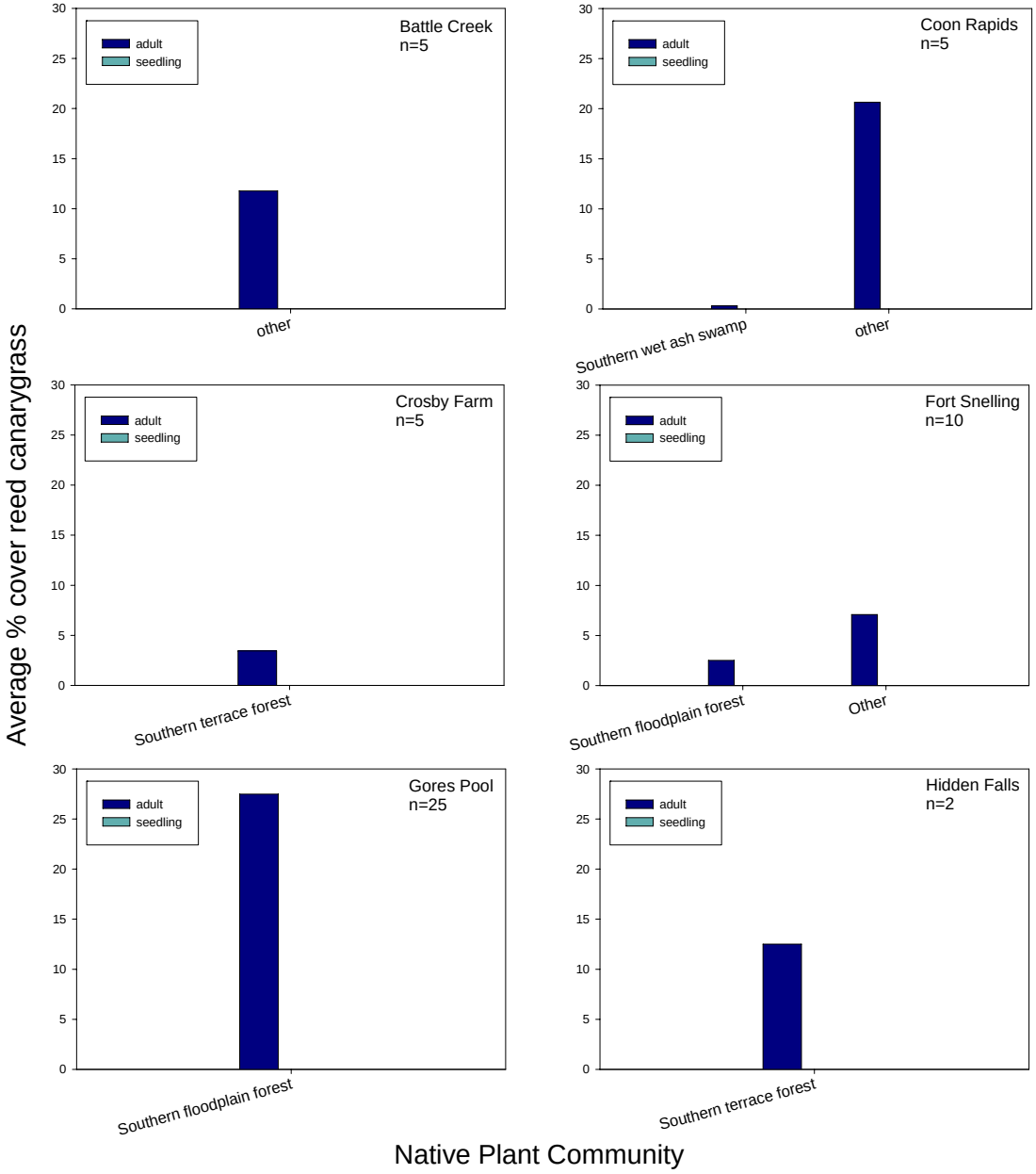


Figure 6. Average percent cover black locust by native plant community at Battle Creek, Coon Rapids Dam, and Mississippi Gorge, 2004. Only adult trees were found. The number of plots sampled at the given park is denoted by "n".

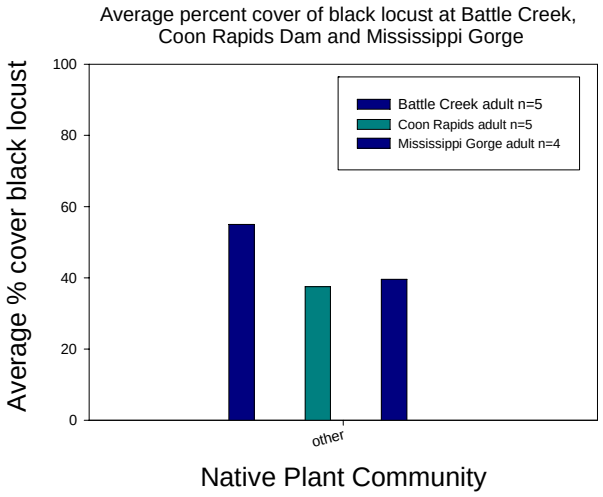


Figure 7. Average percent cover common buckthorn at Saint Croix National Scenic Riverway boat landings and campsites, 2004, by native plant community. Percent cover is separated into adult (>3 m), sapling (<3 m), and seedling (ground cover, not connected by root suckers to any adult or sapling). The number of plots sampled within either boat landings or campsites is listed in parentheses.

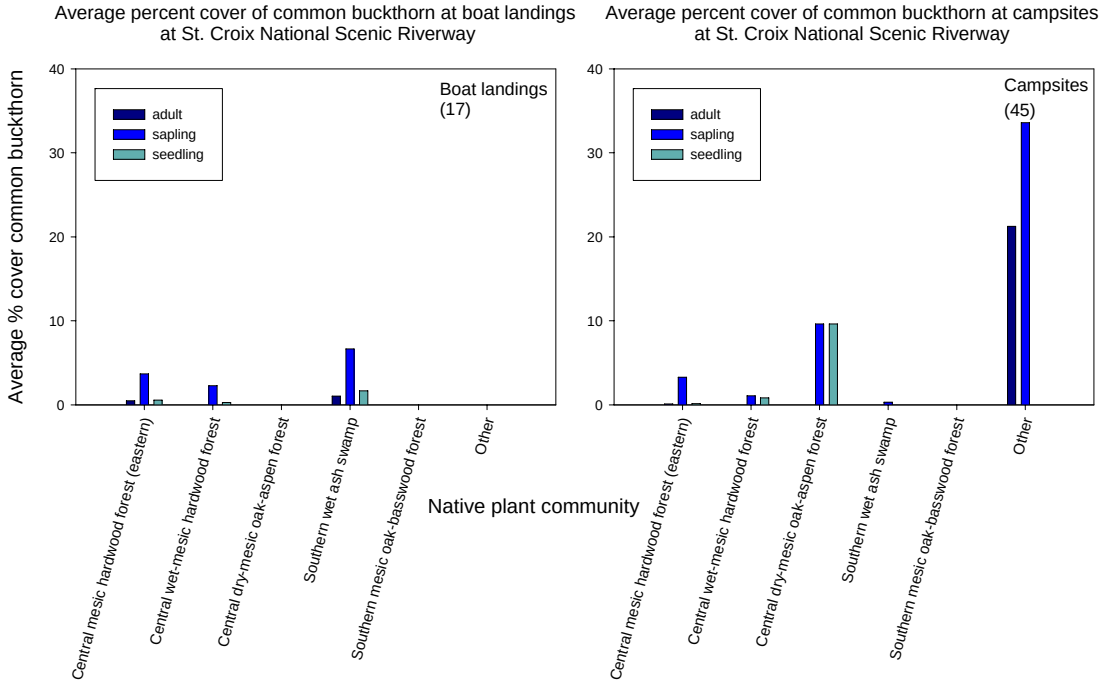


Figure 8. Average percent cover reed canarygrass at Saint Croix National Scenic Riverway boat landings and campsites, 2004, by native plant community. If no bar is present for average percent cover the species was present within the selected plot, but not present in any of the quadrats, which represent a subsample of the plot. Non-woody species are separated into adults or seedlings, the definitions of which vary among species (Table 3). The number of plots sampled within either boat landings or campsites is listed in parentheses.

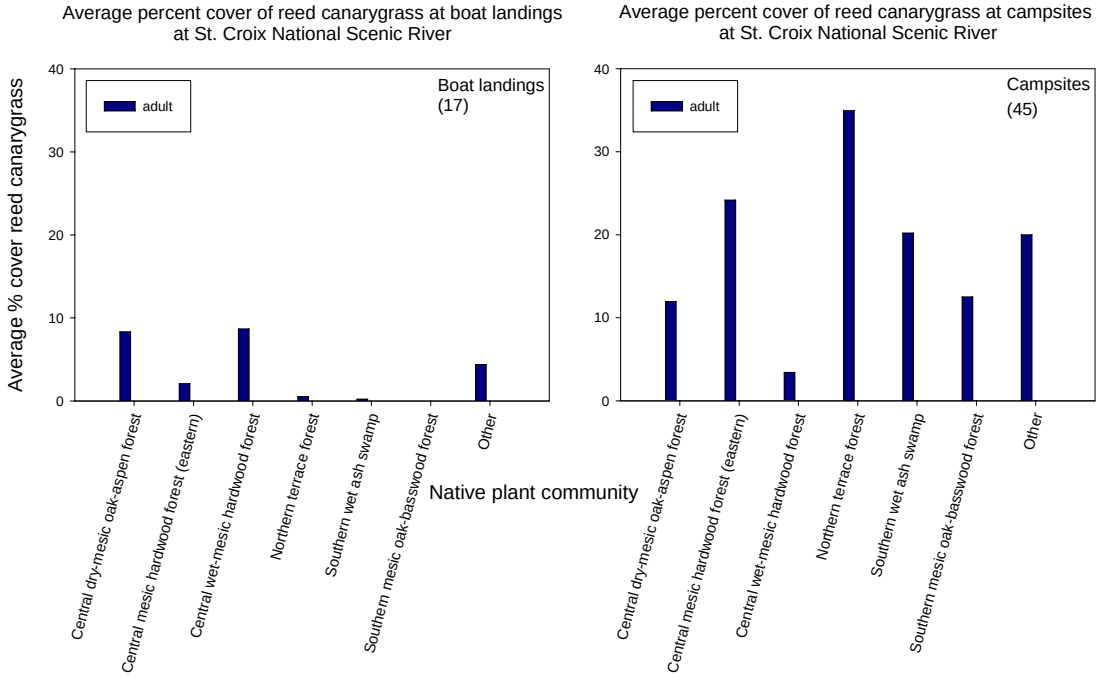


Figure 9. Average percent cover Tartarian honeysuckle at Saint Croix National Scenic Riverway boat landings and campsites, 2004, by native plant community. Percent cover is separated into adult (>1.5 m), sapling (<1.5 m), and seedling (ground cover, not connected by root suckers to any adult or sapling). The number of plots sampled within either boat landings or campsites is listed in parentheses.

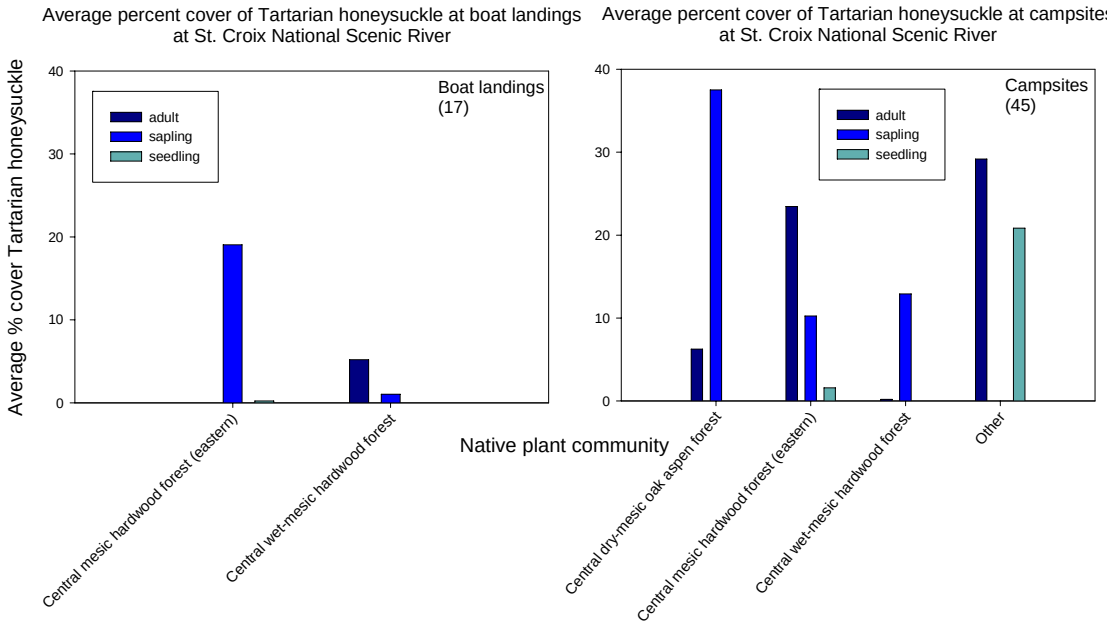


Figure 10. Average percent cover Canada thistle at Saint Croix National Scenic Riverway campsites, 2004, by native plant community. Non-woody species are separated into adults or seedlings, the definitions of which vary among species (Table 3). The number of plots sampled within campsites is listed in parentheses.

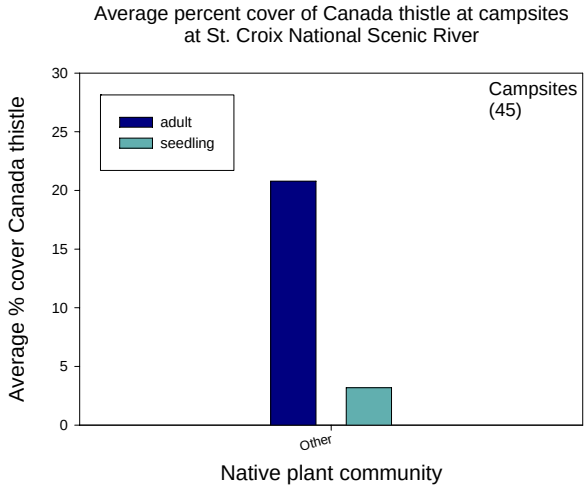
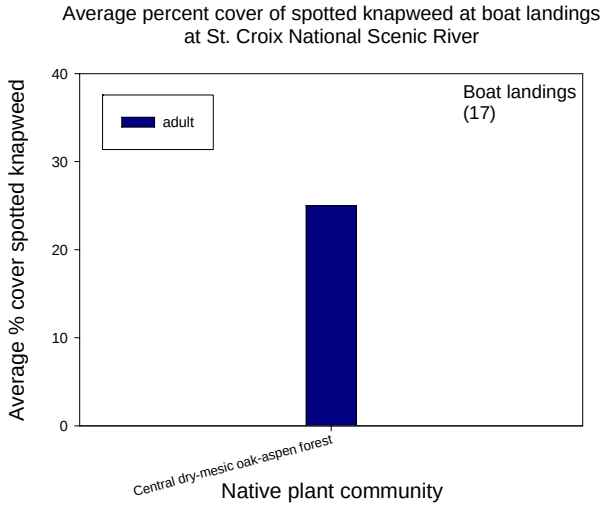


Figure 11. Average percent cover spotted knapweed at Saint Croix National Scenic Riverway boat landings, 2004, by native plant community. Non-woody species are separated into adults or seedlings, the definitions of which vary among species (Table 3). The number of plots sampled within boat landings is listed in parentheses.



At the SACN burn unit, the dominant native species included thick-leaved wild strawberry (*Fragaria virginiana* Duchesne), Canada goldenrod (*Solidago canadensis* L.), and common yarrow (*Achillea millefolium* L.), at 64.29%, 60.71%, and 46.43%, respectively. The most common non-native species included Kentucky bluegrass (*Poa pratensis* L., 78.57%) and

smooth brome (*Bromus inermis* Leyss, 60.71%). Two native grasses were also present but at lower frequencies, including forktip three-awn (*Aristida basiramea* Engelm. ex Vasey, 32.14%) and sand dropseed (*Sporobolus cryptandrus* (Torr.) Gray, 7.14%).

DISCUSSION

Rare Plants

We found very little to add to the database of rare plant occurrences in the two parks. At MISS, the reason is clearly that an efficient system is in place to ensure cataloging of such data in the Natural Heritage database. At SACN, there may be a need for more emphasis on surveys for species of concern. The size and linear nature of the park and the multiple points of public access suggest the need for continued monitoring of such species.

Invasive plants: Mississippi National River and Recreation Area

Within MISS, individual parks varied widely with regard to invasive species number and percent cover (Figures 2-6, Appendix 14). Crosby Farm Nature Area and Gores Pool WMA have few invasive species and low cover, relative to other parks within MISS. With relatively little effort, it should be possible to maintain these sites as representatives of native plant diversity in the absence of exotic invasion.

The majority of infestations at MISS appear in plots which could not be characterized into a native community class (the category "other", Appendix 15). These sites could have had a history of greater disturbance relative to classifiable sites, and therefore may have been more prone to invasion. Land-use history was not taken into account when determining the native plant community class. In any case, invasive vegetation displacing native flora, or altering ecosystem properties in some way to make the site uninhabitable to native flora, could be causing a low native species diversity. Southern floodplain forest, while invaded by garlic mustard, Tartarian honeysuckle, reed canarygrass, and buckthorn, had the lowest invasion rate, with 40.6% of the plots in this community type having no invasive species. Most of the plots in this plant community class were at Gores Pool WMA, and may have flooding cycles that have been little altered by development or water management, allowing for lower rates of invasive species establishment. In many of these sites, the primary groundcover species were silver maple seedlings and wood nettle, which are better adapted to regular flood cycles.

Also worth noting is the difference in age classes of buckthorn, Tartarian honeysuckle, and garlic mustard among parks in MISS. Buckthorn cover at Anoka County Riverfront, Coon Rapids Dam, Fort Snelling, Mississippi Gorge, and Spring Lake Park are all shifting from saplings to adults, whereas cover at Battle Creek and Lake Rebecca is primarily in sapling stage. Adult Tartarian honeysuckle cover was highest at Grey Cloud Dunes, and Mississippi Gorge (87.5% in dry barrens prairie and 12.5% in southern mesic maple basswood, respectively) but only 1 plot was sampled in each of these locations (Appendix 14). However it is still interesting to note the range of plant communities in which this species is able to flourish. Garlic mustard seedling cover at Fort Snelling was sizeable in the southern floodplain forest plant community type (26.3%, 4 plots sampled), indicating that 2005 may be a high seed production year for this biennial species. Mississippi Gorge had a large percent cover of garlic mustard adults in the "other" category (29.0%, 3 plots sampled), adding to a likely extensive seedbank. Many of these differences may be the result of previous management activities, but still reflect life stage dominance at each of the parks.

This was not the first study to assess invasive species infestations at many of the parks within MISS, but it was the first to use standard methods across all parks, made available to resource managers throughout the MISS corridor. While not an exhaustive attempt to survey all invasive infestations, this study can serve as a template for future surveys and to emphasize the importance of continuity to allow compilation and comparison of data across parks.

Invasive Plants: St. Croix Scenic Riverway

Stands of common buckthorn at SACN boat landings and campsites appear relatively young, as evidenced by the higher percentage of saplings and seedlings compared to adults greater than 3 m. Stands of this nature may be the easiest to eradicate, if that is the ultimate goal of the park. The most advanced stands of buckthorn are at campsites which lie in plant communities we could not classify, versus others which were classifiable, where average adult and sapling percent cover were 21.25% and 33.59%, respectively. Unfortunately, no northern border for common buckthorn was found. It was not found past mile marker 83.0, but on the last day of sampling we found seedlings at the Soderbeck East boat landing, 10 miles north of this marker. However, there was a general trend toward lower percent cover of common buckthorn with increasing latitude. Overall there seem to be few dense stands of common buckthorn at SACN. Several possibilities exist: 1) common buckthorn has not had enough time to thoroughly establish, 2) native plant diversity and competition has slowed progress of common buckthorn establishment, or 3) minimal disturbance, except in localized areas including boat landings and campsites, has not opened enough patches for buckthorn establishment.

Reed canarygrass was found in greater percentages at campsites across all native plant communities, when compared to boat landings, and it was present throughout the north-south range of our plots. Tartarian honeysuckle also had greater cover at campsites; central dry-mesic oak-aspen forest had the highest percent cover of all plant communities in campsites, having an average of 37.5% sapling cover of honeysuckle. While this site had the greatest percent cover, only 2 of 7 plots were infested. Central wet-mesic sites had the lowest cover (12.89%) but had the highest number of plots infested (8 of 9 plots sampled within this plant community). Overall, campsites had greater cover of invasive species, with the exception of spotted knapweed (Figures 7-11). This is possibly due to increased disturbance over the landscape, as people are more likely to hike and explore campsite surroundings than areas bordering boat landings, where the majority of time is spent on paved or mowed areas.

Smooth brome and Kentucky bluegrass were the most common non-native species found at the SACN burn unit. Both are cool-season grasses, and may be best controlled by early to late-spring burns (U.S. Forest Service's [USFS] Fire Effects Information System, USFS 2005). Impact on Kentucky bluegrass is greatest following active growing stages, at which time major food-reserves have been depleted. Cool fires, when bluegrass is dormant, have little effect. Impact on smooth brome is greatest after at least five green leaves per tiller have been produced, and in years of high soil moisture, warm-season grasses may out-compete fire-injured smooth brome for water. Late-season fires, which may suppress smooth brome,

also harm legumes. Several legumes, including a vetch species (*Vicia* sp.), and bush clover (*Lespedeza capitata* Michx.) were found at this site. If its root crown is near or at the surface, the native annual grass forktip three-awn will likely decline following any prescribed burn. Sand dropseed has responded positively to early-spring fires, but this species can be rapidly consumed and badly damaged if burned during periods of water stress. Another common native species, Canada goldenrod, responds positively to low to moderate spring fires (USFS 2005).

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Appendix 1. Plant communities sampled at Mississippi National River and Recreation Area and Saint Croix National and Scenic Riverway, descriptions and indicator species. Indicator species listed were not necessarily those used to identify the plant community, but are given as a reference.

Plant community	Description	Indicator species
Southern floodplain forest	Forests obviously within riparian corridor, with features including levees, meander scrolls, and alluvial fans. Woody debris often deposited in piles by floodwater. Ground-layer vegetation dominated by members of the nettle or grass family.	bur cucumber (*Sicyos angulatus* L.), bur marigold (*Bidens cmx*.), false nettle (*Boehmeria cylindrica* L.), northern bugleweed (*Lycopus uniflorus* Michx.)
Southern terrace forest	See floodplain forest description	Jack-in-the-pulpit (*Arisaema triphyllum* (L.) Schott.), Virginia waterleaf (*Hydrophyllum virginianum* L.), touch-me-not (*Impatiens cmx*.)
Southern wet ash swamp	Forests in local low spots or drains. Mucky pools, tip-up mounds, and downed wet logs are the main substrate for ground-layer plants and tree seedlings	box elder (*Acer negundo* L.), wood nettle (*Laportea canadensis* (L.) Widdell), wild geranium (*Geranium maculatum* L.)
Central dry oak-aspen woodland	Commonly the older trees or stumps will have fire-scars. Plants typical of prairies sometimes persistent in the openings.	white oak (*Quercus alba* L.), northern pin oak (*Quercus ellipsoidalis* E. J. Hill), gray dogwood (*Cornus racemosa* Lam.)
Southern mesic maple-basswood forest	Fire-scarred trees generally absent. Natural mature stands uneven-aged with large populations of seedlings of canopy trees.	hackberry (*Celtis occidentalis* L.), white avens (*Geum canadense* Jacq.), Canada moodseed (*Menispermum canadense L.*)
Southern mesic oak-maple forest	See Southern mesic maple-basswood forest description	red baneberry (*Actaea rubra* (Ait) Willd.), long-stalked sedge (*Carex pedunculata* Muhl ex. Willd)
Southern wet-mesic hardwood forest	See Southern mesic maple-basswood forest description	tall coneflower (*Rudbeckia laciniata* L.), stinging nettle (*Urtica dioica* L.), blue phlox (*Phlox divaricata* L.)
Dry barrens prairie	Graminoid-dominated herbaceous community on wind-reworked sands.	silky prairie clover (*Dalea villosa*), Muhlenberg's sedge (*Carex muhlenbergii*), white-haired panic grass (*Panicum commonsianum*)
Dry sand-gravel prairie	Graminoid-dominated, forb-rich herbaceous community on coarse-textured, usually gravelly soils.	side-oats grama (*Bouteloua curtipendula*), plains muhly (*Muhlenbergia cuspidata*), and prairie dropseed (*Sporobolus heterolepis*)
Central dry-mesic oak-aspen forest	Dominated by red oak in the canopy. Well-drained loamy or sandy soils, primarily on stagnation moraines.	lowbush blueberry (*Vaccinium angustifolium* Ait.), tall blackberries (*Rubus allegheniensis* Porter.)
Central mesic hardwood forest	Dominated by basswood,	Jack-in-the-pulpit (*Arisaema*

Plant community	Description	Indicator species
(eastern)	northern red oak, and sugar maple. Present on loamy or sandy loam soils, on hummocky stagnation moraines and rolling till plains	*triphyllum* (L.) Schott.), wild ginger (*Asarum canadense* L.)
Central wet-mesic hardwood forest	On somewhat poorly drained sandy loam soils on till plains and stream terraces. Soils are saturated for prolonged periods.	hooked crowfoot (*Ranunculus recurvatus* Poir.), tall coneflower (*Rudbeckia laciniata* L.), northern blue flag (*Iris versicolor* L.)
Other	could not be determined	

Appendix 2. Column heading descriptions from the MS Access database related to the ArcGIS maps for the Mississippi National River and Recreation Area and Saint Croix National Scenic Riverway.

Column heading	Description
ID	Point identification number
Park system	MISS or SACN
Initials of the observers	JL = Jennifer Larson RT = Roger Tix EB = Elizabeth Brodeen BB = Beverly Braden
Date and time	Date and time of the observation
Park is managed by City, County or State	Park is managed by one of these levels of government, and listed as city, county or state
X	X coordinate; NAD 1983, Zone 15 N
Y	Y coordinate; NAD 1983, Zone 15 N
Name of the park in which you are sampling	Name of the park
Within 20 m of the random point are there buildings	Y or N, disturbance question
Within 20 m of the random point are there roads	Y or N, disturbance question
Within 20 m of the random point are there trails	Y or N, disturbance question
Can you identify the plant community based on Native Plant Communities of Minnesota	Y or N, *Native Plant Communities of Minnesota, the Deciduous Forest Province* or *the Laurentian Mixed Forest Province*
What is the name of the plant community	Based on *Native Plant Communities of Minnesota*
What is the code for the plant community	Based on *Native Plant Communities of Minnesota*
What is the dominant overstory vegetation over 10m	If the plant community could not be identified, the 2 or 3 dominant species over 10 m are listed in this column
What is the dominant understory vegetation under 10m	If the plant community could not be identified, the 2 or 3 dominant species under 10 m are listed in this column
What is the dominant ground cover vegetation	If the plant community could not be identified, the dominant ground cover vegetation is listed in this column
Species present	Scientific name of species of invasive plant surveyed at this point
Does the invasion have a visible edge	Y or N, see possible characterizations in Figure 1.
Can you perform cover estimates every 3 meters and fit 6 quadrats within the infestation	Y or N, see possible characterizations in Figure 1.
If the invasion is too small to perform quadrat estimates what is the percent cover of ADULTS in the entire infestation	7 categories – 0, 2.5, 12.5, 37.5, 62.5, 87.5, 97.5, based on midpoints of Daubenmire categories
Percent cover of SAPLINGS in the entire infestation	7 categories – 0, 2.5, 12.5, 37.5, 62.5, 87.5, 97.5
Percent cover of SEEDLINGS in the entire infestation	7 categories – 0, 2.5, 12.5, 37.5, 62.5, 87.5, 97.5
A1…A12 Is the quadrat in the plot	Y or N, see possible characterizations in Figure 1
A1…A12 Percent cover of invasive ADULTS	7 categories – 0, 2.5, 12.5, 37.5, 62.5, 87.5, 97.5
A1…A12 Percent cover of invasive SAPLINGS	7 categories – 0, 2.5, 12.5, 37.5, 62.5, 87.5, 97.5
A1…A12 Percent cover of invasive SEEDLINGS	7 categories – 0, 2.5, 12.5, 37.5, 62.5, 87.5, 97.5
Is there an invasive species map associated with this plot	Y or N – if the invasion was confined to a definable patch, the perimeter of it was mapped on a GPS unit.

Appendix 3. Average percent cover of common buckthorn at each park sampled in Mississippi National River and Recreation Area, 2004, by life stage and native plant community. Blue numbers in parentheses indicate number of plots that had buckthorn in each park in the given plant community / total number of plots in each park in the same plant community.

Name of the park	Life stage	Central dry oak-aspen woodland	Southern floodplain forest	Southern mesic maple-basswood forest	Southern mesic oak-maple forest	Southern terrace forest	Southern wet ash swamp	Southern wet-mesic hardwood forest	other
Anoka County Riverfront	Adult								19.58 (1/1)
	Sapling								6.67
	Seedling								2.50
Battle Creek	Adult	0 (1/1)							10.68 (4/4)
	Sapling	25.42							22.39
	Seedling	0							0.23
Coon Rapids Dam	Adult			57.08 (1/1)		0.00 (1/1)	6.46 (1/1)		4.48 (2/2)
	Sapling			18.33		0.83	0.00		7.60
	Seedling			1.46		0.42	0.00		1.04
Crosby Farm	Adult					1.41 (1/5)			
	Sapling					1.56			
	Seedling					0.21			
Fort Snelling	Adult		0.42 (3/4)		31.67 (1/1)	0.00 (2/2)	17.40 (2/2)		1.56 (1/1)
	Sapling		2.60		15.00	7.19	1.88		0.94
	Seedling		0.56		0.00	0.52	0.63		1.25
Hidden Falls	Adult					0.00 (1/1)			23.13 (1/1)
	Sapling					1.25			1.04
	Seedling					0.00			0.21
Lake Rebecca	Adult						2.50 (1/1)		
	Sapling						15.42		
	Seedling						0.63		
Lilydale	Adult			0.00 (1/1)					1.04 (1/1)
	Sapling			1.25					0.83
	Seedling			0.00					0.00
Minnehaha	Adult								0.00 (1/1)
	Sapling								2.08
	Seedling								0.00
Mississippi Gorge	Adult			5.21 (1/1)					25.69 (3/3)
	Sapling			0.21					1.11
	Seedling			0.00					0.14

Mississippi NRRA and St. Croix NSR rare and exotic plants

Name of the park	Life stage	Central dry oak-aspen woodland	Southern floodplain forest	Southern mesic maple-basswood forest	Southern mesic oak-maple forest	Southern terrace forest	Southern wet ash swamp	Southern wet-mesic hardwood forest	other
North Mississippi	Adult								2.50
	Sapling								3.33
	Seedling								1.25
Spring Lake Park	Adult							19.58 (2/2)	19.33 (2/2)
	Sapling							4.58	3.87
	Seedling							0.10	0.32

Appendix 4. Average percent cover of Tartarian honeysuckle at each park sampled in Mississippi National River and Recreation Area, 2004, by life stage and native plant community. Blue numbers in parentheses indicate number of plots that had honeysuckle in each park in the given plant community / total number of plots in each park in the same plant community.

Name of the park	Life stage	Central dry oak-aspen woodland	Dry barrens prairie	Dry sand-gravel prairie	Southern floodplain forest	Southern mesic maple-basswood forest	Southern mesic oak-maple forest	Southern wet ash swamp	other
Anoka County Riverfront	Adult								4.17 (1/1)
	Sapling								3.75
	Seedling								0.00
Battle Creek	Adult	0.00 (1/1)							2.92 (3/4)
	Sapling	4.69							20.90
	Seedling	0.00							0.00
Coon Rapids Dam	Adult					5.21 (1/1)		0.00 (1/1)	2.60 (2/2)
	Sapling					0.00		1.04	1.15
	Seedling					0.21		0.00	0.00
Fort Snelling	Adult				0 (2/4)		11.88 (1/1)		
	Sapling				18.75		1.25		
	Seedling				0		0.00		
Grey Cloud Dunes SNA	Adult		87.50 (1/1)	0.21 (1/1)					
	Sapling		12.50	0.21					
	Seedling		0.00	0.00					
Lake Rebecca	Adult							0.00 (1/1)	
	Sapling							1.04	
	Seedling							0.00	
Lilydale	Adult					0.00 (1/1)			
	Sapling					4.79			
	Seedling					0.00			
Minnehaha	Adult								0.00 (1/1)
	Sapling								37.50
	Seedling								0.00
Mississippi Gorge Regional Park	Adult					12.50 (1/1)			0.07 (3/3)
	Sapling					0.00			0.07
	Seedling					0.00			0.00

Name of the park	Life stage	Central dry oak-aspen woodland	Dry barrens prairie	Dry sand-gravel prairie	Southern floodplain forest	Southern mesic maple-basswood forest	Southern mesic oak-maple forest	Southern wet ash swamp	other
Spring Lake Park	Adult								0.11 (2/2)
	Sapling								7.64
	Seedling								0.22

Appendix 5. Average percent cover of garlic mustard at each park sampled in Mississippi National River and Recreation Area, 2004, by life stage and native plant community. Blue numbers in parentheses indicate number of plots that had garlic mustard in each park in the given plant community / total number of plots in each park in the same plant community.

Name of the park	Life stage	Central dry oak-aspen woodland	Southern floodplain forest	Southern mesic maple-basswood forest	Southern terrace forest	Southern wet ash swamp	other
Battle Creek	Adult	1.04 (1/1)					2.71 (2/4)
	Seedling	1.04					20.73
Coon Rapids Dam	Adult			0.00 (1/1)		7.71 (1/1)	0.00 (1/2)
	Seedling			0.00		3.13	0.00
Crosby Farm	Adult				0.63 (4/5)		
	Seedling				9.64		
Fort Snelling	Adult		0.83 (3/4)		0.00 (1/2)	0.21 (1/2)	
	Seedling		26.32		1.88	10.83	
Hidden Falls	Adult				0.21 (1/1)		17.92 (1/1)
	Seedling				18.33		24.58
Minnehaha	Adult						5.21 (1/1)
	Seedling						7.08
Mississippi Gorge Regional Park	Adult						28.96 (1/3)
	Seedling						4.38
North Mississippi Regional Park	Adult						14.79 (1/1)
	Seedling						3.75

Appendix 6. Average percent cover of reed canarygrass at each park sampled in Mississippi National River and Recreation Area, 2004, by life stage native plant community. Blue numbers in parentheses indicate number of plots that had reed canarygrass in each park in the given plant community / total number of plots within each park in the same plant community.

Name of the Park	Life stage	Southern floodplain forest	Southern terrace forest	Southern wet ash swamp	other
Battle Creek	ADULT				11.77 (2/4)
	SEEDLING				0.00
Coon Rapids Dam	ADULT			0.31 (1/1)	20.63 (1/2)
	SEEDLING			0.00	0.00
Crosby Farm	ADULT		3.44 (1/5)		
	SEEDLING		0.00		
Fort Snelling	ADULT	2.50 (1/4)			7.08 (1/1)
	SEEDLING	0.00			0.00
Gores Pool WMA	ADULT	27.47 (10/24)			
	SEEDLING	0.00			
Hidden Falls	ADULT		12.50 (1/1)		
	SEEDLING		0.00		

Appendix 7. Average percent cover of black locust at each park sampled in Mississippi National River and Recreation Area, 2004, by life stage and native plant community. Blue numbers in parentheses indicate number of plots that had black locust in each park in the given plant community / total number of plots in each park in the same plant community.

Name of the park	Life stage	Other
Battle Creek	ADULT	55.00 (1/4)
	SAPLING	0.00
	SEEDLING	0.00
Coon Rapids Dam	ADULT	37.50 (1/2)
	SAPLING	0.00
	SEEDLING	0.00
Mississippi Gorge Regional Park	ADULT	39.58 (1/3)
	SAPLING	0.00
	SEEDLING	0.00

Appendix 8. Average percent cover of common buckthorn at boat landings or campsites sampled in Saint Croix National Scenic Riverway, 2004, by life stage and native plant community. Blue numbers in parentheses indicate the number of plots sampled in boat landings or campsites that had common buckthorn, in the given plant community / total number of plots sampled in either boat landings or campsites, in the same plant community.

Site	Life stage	Central dry-mesic oak-aspen forest	Central mesic hardwood forest (eastern)	Central wet-mesic hardwood forest	Northern terrace forest	Northern wet-mesic hardwood forest	Southern mesic oak-basswood forest	Southern terrace forest	Southern wet ash swamp	other
Boat landing	ADULT		0.49 (3/3)	0.00 (3/3)	0.00 (2/2)	0.00 (1/1)		5.00 (4/4)	1.04 (1/1)	
	SAPLING		3.68	2.29	0.73	0.00		12.34	6.67	
	SEEDLING		0.56	0.28	0.00	37.50		0.26	1.67	
Campsite	ADULT	0.00 (4/7)	0.09 (11/13)	0.00 (8/8)			0.00 (1/1)		0.00 (1/3)	21.25 (3/9)
	SAPLING	9.64	3.28	1.08			0.00		0.31	33.59
	SEEDLING	9.64	0.15	0.81			0.00		0.00	0.00

Appendix 9. Average percent cover of reed canarygrass at boat landings or campsites sampled in Saint Croix National Scenic Riverway, 2004, by life stage and native plant community. Blue numbers in parentheses indicate the number of plots sampled in boat landings or campsites that had reed canarygrass, in the same plant community / total number of plots sampled in boat landings or campsites, in the given plant community.

Site	Life stage	Central dry-mesic oak-aspen forest	Central mesic hardwood forest (eastern)	Central wet-mesic hardwood forest	Northern terrace forest	Southern mesic oak-basswood forest	Southern terrace forest	Southern wet ash swamp	other
Boat landing	ADULT	8.33 (1/2)	2.08 (2/3)	8.68 (3/3)	0.52 (2/2)		7.99 (4/4)	0.21 (1/1)	4.38 (1/1)
	SEEDLING	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Campsite	ADULT	11.94 (3/7)	24.17 (3/13)	3.42 (5/8)	34.95 (2/2)	12.5 (1/1)		20.21 (2/3)	20 (2/9)
	SEEDLING	0.00	0.00	0.00	0.00	0.00		0.00	0.00

Appendix 10. Average percent cover of Tartarian honeysuckle at boat landings or campsites sampled in Saint Croix National Scenic Riverway, 2004, by life stage and native plant community. Blue numbers in parentheses indicate the number of plots sampled in boat landings or campsites that had honeysuckle, in the same plant community / total number of plots sampled in boat landings or campsites, in the given plant community.

Site	Life stage	Central dry-mesic oak-aspen forest	Central mesic hardwood forest (eastern)	Central wet-mesic hardwood forest	other
Boat landing	ADULT		0.00 (2/3)	5.21 (1/3)	
	SAPLING		19.07	1.04	
	SEEDLING		0.21	0.00	
Campsite	ADULT	6.25 (2/7)	23.44 (8/13)	0.18 (7/8)	29.17 (3/9)
	SAPLING	37.5	10.23	12.89	0.00
	SEEDLING	0.00	1.59	0.00	20.83

Appendix 11. Average percent cover of Canada thistle at campsites sampled in Saint Croix National Scenic Riverway, 2004, by life stage and native plant community. Blue numbers in parentheses indicate the number of plots sampled at campsites that had Canada thistle, in the given plant community / total number of plots sampled in either boat landings or campsites, in the same plant community. Boat landings are not present in this table due to lack of Canada thistle near boat landings within the "other" native plant community designation.

Site	Life stage	Other
Campsite	ADULT	20.78 (4/9)
	SEEDLING	3.18

Appendix 12. Average percent cover of spotted knapweed at boat landings or campsites sampled in Saint Croix National Scenic Riverway, 2004, by life stage and native plant community. Blue numbers in parentheses indicate the number of plots sampled in boat landings or campsites that had spotted knapweed, in the given plant community / total number of plots sampled in either boat landings or campsites, in the same plant community. Campsites are not present in this table due to lack of spotted knapweed near campsites within the "Central dry-mesic oak-aspen forest."

Site	Life stage	Central dry-mesic oak-aspen forest
Boat landing	ADULT	25.00 (2/2)
	SEEDLING	0.00

Appendix 13. Relative frequency of invasive species at the burn unit sampled for Saint Croix National Scenic Riverway, 2004.

Species	Common name	Relative frequency
Poa pratensis	Kentucky bluegrass	78.57
Fragaria virginiana	thick-leaved wild strawberry	64.29
Solidago canadensis	Canada goldenrod	60.71
Bromus inermis	smooth brome	60.71
Achillea millefolium	common yarrow	46.43
unknown forb	unknown forb	42.86
Solidago sp.	goldenrod	39.29
Ambrosia artemisiifolia	common ragweed	35.71
Aristida basiramea	forktip three-awn	35.71
Setaria spp.	foxtail-grass	35.71
Agropyron sp.	wheatgrass	35.71
Potentilla sp.	cinquefoil or five-fingers	32.14
Euphorbia corollata	flowering spurge	32.14
Vicia sp.	vetch	32.14
Parthenocissus cf. quinquefolia	Virginia creeper	32.14
Acer negundo	box elder	28.57
Rubus idaeus	red raspberry	28.57
Convolvulus sp.	morning glory	25.00
Dicanthelium sp.	Dicanthelium (formerly Panicum species)	21.43
Ulmus americana	American elm	17.86
Rhamnus cathartica	common buckthorn	17.86
Zanthoxylum americanum	prickly ash	17.86
Hedeoma hispidum	rough false pennyroyal	17.86
unknown rosette	unknown rosette	17.86
unknown seedling	unknown seedling	17.86
Trifolium repens	white clover	17.86
Acer sp.	maple variety	14.29
Aster sp.	aster	14.29
Lespedeza capitata	bush-clover	14.29
Rhus glabra	smooth sumac	14.29
unknown fern	unknown fern	14.29
unknown grass	unknown grass	14.29
Asclepias verticillata	whorled milkweed	14.29
Vitis riparia	frost grape	10.71
Fraxinus pennsylvanica	green ash	10.71
Berteroa incana	hoary alyssum	10.71
Asclepias sp.	milkweed	10.71
Galium aparine	cleavers	7.14
Sporobolus cryptandrus	sand dropseed	7.14
Cirsium species	thistle	7.14
unknown woody	unknown woody	7.14
Eupatorium sp.	white snakeroot	7.14
Oxalis sp.	wood-sorrel	7.14
Teucrium canadense	American germander	3.57
Prunus serotina	black cherry	3.57
Taraxacum officinale	common dandelion	3.57
Circaea lutetiana	common enchanter's nightshade	3.57
Ribes cynosbati	dogberry, also prickly gooseberry	3.57

Species	Common name	Relative frequency
Cornus sp.	dogwood species	3.57
Hieracium sp.	hawkweed	3.57
Amphicarpaea bracteata	hog peanut	3.57
Equisetum sp.	horsetail	3.57
Conyza canadensis	horse-weed	3.57
Populus tremuloides	quaking aspen	3.57
Rosa sp.	rose	3.57
Carex sp.	sedge	3.57
Acer saccharinum	silver maple	3.57
Urtica dioica	stinging nettle	3.57
Fragaria spp.	strawberry	3.57
Osmorhiza sp.	sweet cicely	3.57
Lonicera tatarica	Tartarian honeysuckle	3.57
unknown lettuce	unknown lettuce	3.57
unknown mustard	unknown mustard	3.57
unknown shrub	unknown shrub	3.57
unknown shrub(2)	unknown shrub (2)	3.57
unknown vine	unknown vine	3.57

Appendix 14. Invasive plant species found at each park at the Mississippi National River and Recreation Area, 2004, and the number of plots per park infested with the given species. The number of plots sampled at each park is listed in parentheses.

Park	Species	Number of plots per park with listed species
Anoka County Riverfront Regional Park (1)	Tartarian honeysuckle	1
	Common buckthorn	1
Battle Creek (5)	Garlic mustard	3
	Canada thistle	1
	Tartarian honeysuckle	4
	Reed canarygrass	2
	Common buckthorn	5
	Black locust	1
Coon Rapids Dam (5)	Garlic mustard	3
	Tartarian honeysuckle	4
	Reed canarygrass	2
	Common buckthorn	5
	Black locust	1
Crosby Farm (5)	Garlic mustard	4
	Canada thistle	1
	None	1
	Reed canarygrass	1
	Common buckthorn	4
Fort Snelling (10)	Garlic mustard	5
	Tartarian honeysuckle	3
	None	1
	Reed canarygrass	2
	Common buckthorn	9
Gores Pool WMA (25)	None	13
	Reed canarygrass	10
Grey Cloud Dunes SNA (2)	Smooth brome	2
	Spotted knapweed	2
	Tartarian honeysuckle	2
	Russian thistle	1
Hidden Falls (2)	Garlic mustard	2
	Reed canarygrass	1
	Common buckthorn	2
Lake Rebecca (1)	Tartarian honeysuckle	1
	Common buckthorn	1
Lilydale (2)	Tartarian honeysuckle	2
	Common buckthorn	2
Minnehaha (1)	Garlic mustard	1
	Tartarian honeysuckle	1
	Common buckthorn	1
Mississippi Gorge Regional Park (4)	Garlic mustard	1
	Tartarian honeysuckle	4
	Common buckthorn	4
	Black locust	1
North Mississippi Regional Park (1)	Garlic mustard	1
	Nodding thistle	1
	Canada thistle	1
	Common buckthorn	1

Spring Lake Park (4)	Tartarian honeysuckle	4
	Common buckthorn	4

Appendix 15. Invasive plant species found in each plant community within the Mississippi National River and Recreation Area, 2004, and the number of plots per community infested with the given species.

Plant community	Invasive species	Number of occurrences within plant community
Central dry oak-aspen woodland	Garlic mustard	1
(1)	Tartarian honeysuckle	1
	Common buckthorn	1
Dry barrens prairie	Smooth brome	1
(1)	Spotted knapweed	1
	Tartarian honeysuckle	1
	Russian thistle	1
Dry sand-gravel prairie	Smooth brome	1
(1)	Spotted knapweed	1
	Tartarian honeysuckle	1
other	Garlic mustard	7
(18)	Nodding thistle	1
	Canada thistle	2
	Tartarian honeysuckle	12
	None	1
	Reed canarygrass	4
	Common buckthorn	17
	Black locust	3
Southern floodplain forest	Garlic mustard	3
(28)	Tartarian honeysuckle	2
	None	13
	Reed canarygrass	11
	Common buckthorn	3
Southern mesic maple-basswood forest	Garlic mustard	1
(3)	Tartarian honeysuckle	4
	Common buckthorn	3
Southern mesic oak-maple forest	Tartarian honeysuckle	1
(1)	Common buckthorn	1
Southern terrace forest	Garlic mustard	6
(9)	Canada thistle	1
	None	1
	Reed canarygrass	2
	Common buckthorn	8
Southern wet ash swamp	Garlic mustard	2
(4)	Tartarian honeysuckle	2
	Reed canarygrass	1
	Common buckthorn	4
Southern wet-mesic hardwood forest	Tartarian honeysuckle	2
(2)	Common buckthorn	2